clean tomorrow | Re-Energizing America

The Ten Technology Pillars of Energy Innovation

Technology Pillars

In 2020, Columbia University and the Information Technology and Innovation Foundation's *Energizing America* identified 10 technology pillars for which federal innovation support would advance our nation toward its goals of deep decarbonization and economic opportunity.[1] In the years since its publication, rapidly rising energy prices and an evolving geopolitical order have expanded the urgency for energy innovation to address affordability and national security. Our updated technology pillars reflect this broadened set of policy criteria. Listed below, the pillars are described in more detail in the following pages.

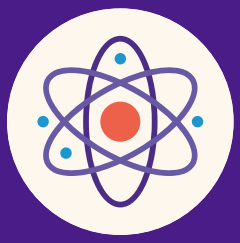
These pillars are not technology-specific; instead, they advance outcomes or services that a range of technologies can perform. Each includes a broad array of technologies at different levels of market readiness. Within each pillar, types and levels of federal funding for specific technologies will vary based on what is needed for that sector and their progression along the commercialization pipeline.

At a more tactical level, specific technologies within each pillar should be assessed regularly by experts. If progress has stalled, funding should be redirected toward more promising technologies. If progress has been made, new funding mechanisms (such as cost-shared partnerships) or policy tools (such as tax incentives for technology adoption) may be in order. Technology and adoption readiness frameworks, such as those used by the International Energy Agency and DOE Liftoff Reports, can provide helpful guidance, although no algorithm can fully substitute for well-informed, deliberative technical judgments.[2, 3]

TABLE 1. Re-Energizing America's 10 technology pillars.

1	Foundational science and platform technologies
2	Secure, efficient, digitally enabled power systems
3	Clean firm electricity generation
4	Variable electricity generation
5	Advanced transportation systems
6	Sustainable fuels
7	Efficient buildings
8	Clean and competitive manufacturing
9	Secure supply chains
10	Carbon management

Technology Pillars for Re-Energizing Energy Innovation



Pillar 1: Foundational science and platform technologies

Foundational scientific research across a range of fields can enable breakthroughs in energy technologies—nuclear power, which emerged from basic physics, is the quintessential example. The United States is a world leader in basic scientific RD&D investments and must continue to foster investigator-driven discovery to unlock revolutionary opportunities.[4] This pillar includes advanced materials, electrochemistry, and quantum computing, in addition to platform technologies, such as machine learning, smart manufacturing, and digitalization, which are essential to bring our energy systems into the modern moment.

Pillar 2: Secure, efficient, digitally enabled power systems

Secure, efficient, digitally enabled power systems are the cornerstone of this century's economy. Rising electricity demand and aging infrastructure create urgency and an opportunity to accelerate grid innovation to meet the needs of artificial intelligence data centers, clean and competitive manufacturing, and electric vehicles, all while ensuring affordability, reliability, and security for everyday Americans.[5] This pillar includes advanced grid technologies and components, electricity transmission, storage, grid and energy system cybersecurity, virtual power plants, and system integration and planning.

Pillar 3: Clean firm electricity generation

Clean firm electricity generation refers to power generators that can produce electricity around-the-clock with low emissions and high certainty. Affordable technologies of this type are essential to power work, transportation, manufacturing, education, and many other activities. Clean firm technologies are also major domains of competition for global influence with China.[6] Emerging technologies such as advanced nuclear fission, fusion energy, and enhanced geothermal fall under this pillar.

Pillar 4: Variable electricity generation

Electricity generation based on variable natural inputs, such as solar and wind power, has made tremendous strides in recent years. Variable renewable energy technologies account for the majority of new capacity being installed on grids in the United States and around the world.[7] These technologies continue to advance at a remarkable rate, and global markets dominated by Chinese firms continue to grow rapidly. Key opportunities in next-generation renewable technologies under this pillar include tandem and flexible photovoltaics, floating wind, and marine and tidal energy.

Pillar 5: Advanced transportation systems

Autonomous, connected, and electrified systems are disrupting the world's transportation industries. China has seized a commanding early lead in the development and deployment of technologies for rapid charging, range extension, and low-cost production. However, many chapters of this story remain to be written.[8] This pillar encompasses all modes of transportation, including medium and heavy-duty trucking, maritime, air, and rail as well as passenger vehicles.

Pillar 6: Sustainable fuels

Sustainable fuels can strengthen the security, reliability, and affordability of the fuels used in transportation, industry, agriculture, and other key sectors of the economy, while also reducing pollution. Unabated fossil fuel combustion not only creates greenhouse gases, but it also leaves the United States dependent on volatile global markets, major increases in domestic oil and gas production notwithstanding. Work under this pillar may include advanced biofuels, synthetic hydrocarbons, and hydrogen and ammonia made with carbon capture and sequestration (CCS), clean electricity, or waste sources.

Pillar 7: Efficient buildings

Residential and commercial buildings, directly and through use of electricity, are responsible for about 40% of U.S. energy consumption. Deploying advanced technologies developed and championed by U.S. innovators means less energy use, lower costs, greater comfort, and improved health for Americans. Advanced technologies can even turn buildings into interactive resources for the power grid. This pillar focuses on using advanced technologies like ground-source heat pumps, improved building envelopes, and smart sensors and controls that enable buildings to use less energy and reduce system costs.

Pillar 8: Clean and competitive manufacturing

Global markets increasingly demand high-quality goods that meet strict sustainability standards. Many U.S. manufacturers are meeting this multi-faceted challenge but face stiff international competition going forward. This pillar touches a wide range of sectors, including heavy industries like chemicals, steel, and cement, as well as process innovations ranging from artificial intelligence applications and robotics to electrification and clean heat. It also includes advanced manufacturing of energy system goods, such as power system components and vehicles.

Pillar 9: Secure supply chains

Supply chain vulnerabilities became apparent during the COVID pandemic, when supply shocks sparked inflation and limited availability of vital goods. The experience laid bare U.S. dependence on China—a threat reinforced by new export controls on critical minerals. This pillar requires innovation in fields like battery chemistry, natural resource exploration and extraction, and materials processing and recycling.

Pillar 10: Carbon management

Carbon management is a new discipline that provides an opportunity to mitigate emissions from hard-to-abate sectors, including industry, power, and aviation. The United States is currently poised to be a global leader in developing carbon management technologies due to expertise in fossil fuel infrastructure and significant investments over the past several years, yet currently risks ceding its position to other countries. This pillar encompasses carbon management at the facility and regional level through carbon capture, utilization, and storage, as well as at the global level through removal of carbon dioxide and methane from the atmosphere.

Several of these pillars are similar to those in *Energizing America*, including foundational science and platform technologies, transportation, fuels, buildings, and manufacturing. The power systems pillar is updated to reflect an increased focus on grid reliability, security, and modernization. We divide *Energizing America*'s single electricity generation pillar into two—clean firm and variable generation—to emphasize the need for innovation to meet rising electricity demand and balance a growing variable renewables portfolio. We have combined *Energizing America*'s two pillars on carbon capture, use, and sequestration and carbon dioxide removal (from the atmosphere) into one on carbon management. Finally, we have added a new pillar on secure supply chains to respond to threats to critical minerals, materials, and components used in energy innovations.

1 Varun Sivaram et al., "Energizing America: A Roadmap to Launch a National Energy Innovation Mission," Columbia University SIPA Center on Global Energy Policy, September 2, 2020. https://www.energypolicy.columbia.edu/wp-content/uploads/2021/01/ETMO-commentary-designed-v2-1.19.21-1.pdf

2 International Energy Agency (IEA), "ETP Clean Energy Technology Guide," last updated April 2, 2025. https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide

3 While the Liftoff Reports were removed from DOE's website under the Trump administration, they were briefly reinstated during summer 2025. A database of the reports can be found on Yardsale Energy: https://yardsale.energy/liftoff-reports/

4 National Science Foundation, "Research and Development: U.S. Trends and International Comparisons," NSB 2024-6, 2024. https://ncses.nsf.gov/pubs/nsb20246

5 U.S. Energy Information Administration (EIA), "After more than a decade of little change, U.S. electricity consumption is rising again," May 13, 2025. https://www.eia.gov/todayinenergy/detail.php?id=65264

6 Stephen Ezell, "How Innovative is China in Nuclear Power?" Information Technology & Innovation Foundation (ITIF), June 17, 2024. https://itif.org/publications/2024/06/17/how-innovative-is-china-in-nuclear-power/

7 International Energy Agency (IEA), "World Energy Investment 2025," June 2025. https://www.iea.org/reports/world-energy-investment-2025

8 Stephen Ezell, "How Innovative Is China in the Electric Vehicle and Battery Industries?" Information Technology & Innovation Foundation (ITIF), July 29, 2024. https://itif.org/publications/2024/07/29/how-innovative-is-china-in-the-electric-vehicle-and-battery-industries/